Azimuthal Anisotropy Measurements from Cumulants in PHENIX

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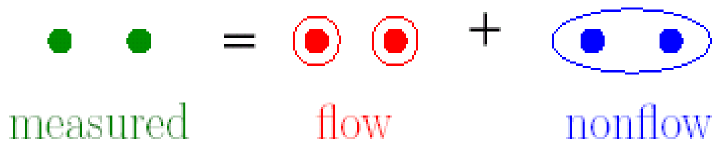
Introduction

- Azimuthal anisotropy : sensitive to early pressure build-up and hence to the equation of state
- Detailed measurements of v_2 can assist in discriminating between different sources of the anisotropy
- Standard methods to calculate v_2 : reaction plane and two-particle correlations
- Cumulant method: cumulants of multiparticle azimuthal correlations are related to flow harmonics [Borghini et al., PRC 64, 054901]

Cumulant Method

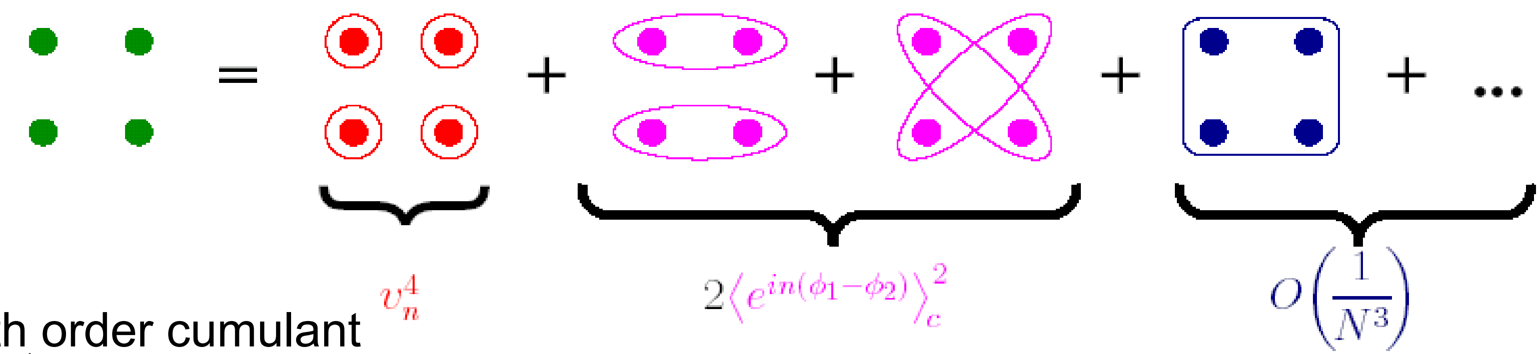


$$\left\langle e^{in(\varphi_1-\varphi_2)} \right\rangle_m = v_n^2 + \left\langle e^{in(\varphi_1-\varphi_2)} \right\rangle_c$$

$$\langle\langle e^{2i(\phi_1-\phi_2)} \rangle\rangle \equiv c_2\{2\} = v_2^2$$

Second order cumulant

If flow predominates, cumulants of higher order can be used to reduce non-flow contributions

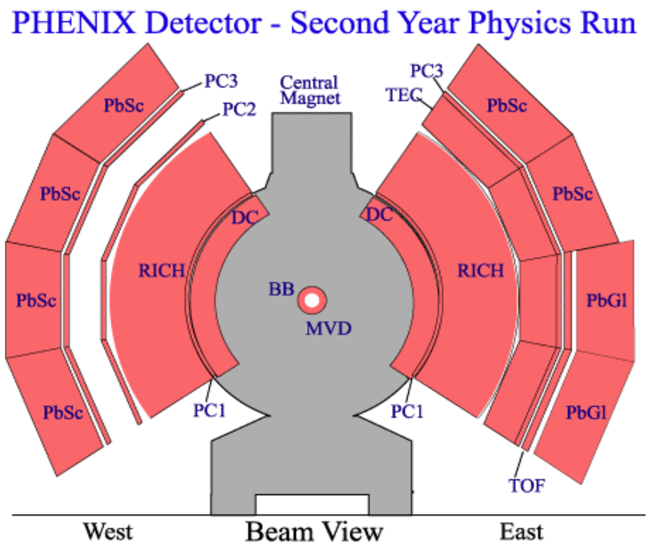


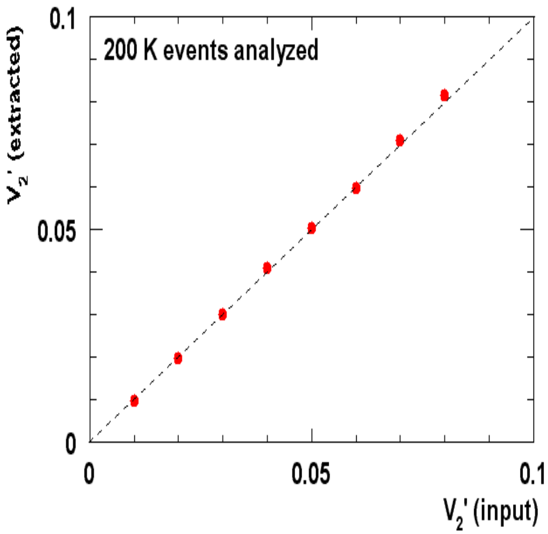
Fourth order cumulant

$$c_n\{4\} = \left\langle e^{in(\varphi_1+\varphi_2-\varphi_3-\varphi_4)} \right\rangle - \left\langle e^{in(\varphi_1-\varphi_2)} \right\rangle \left\langle e^{in(\varphi_3-\varphi_4)} \right\rangle - \left\langle e^{in(\varphi_1-\varphi_4)} \right\rangle \left\langle e^{in(\varphi_3-\varphi_2)} \right\rangle \approx -v_n^4$$

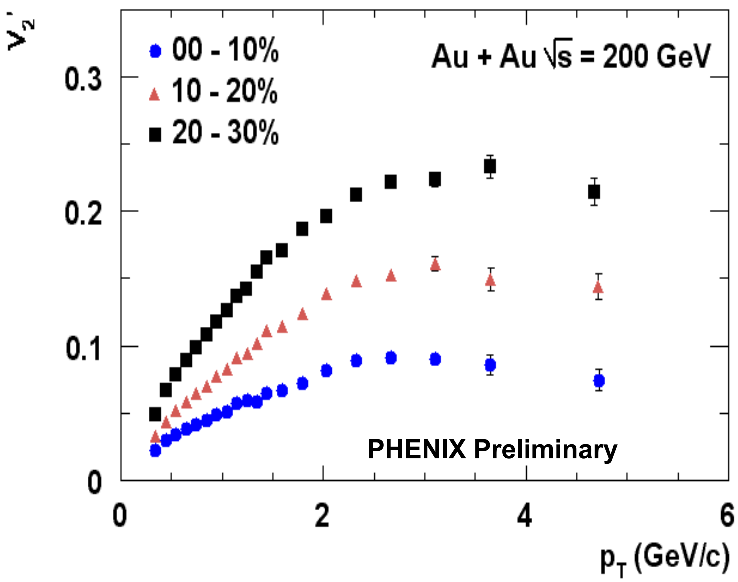
Application of Cumulant Method in PHENIX

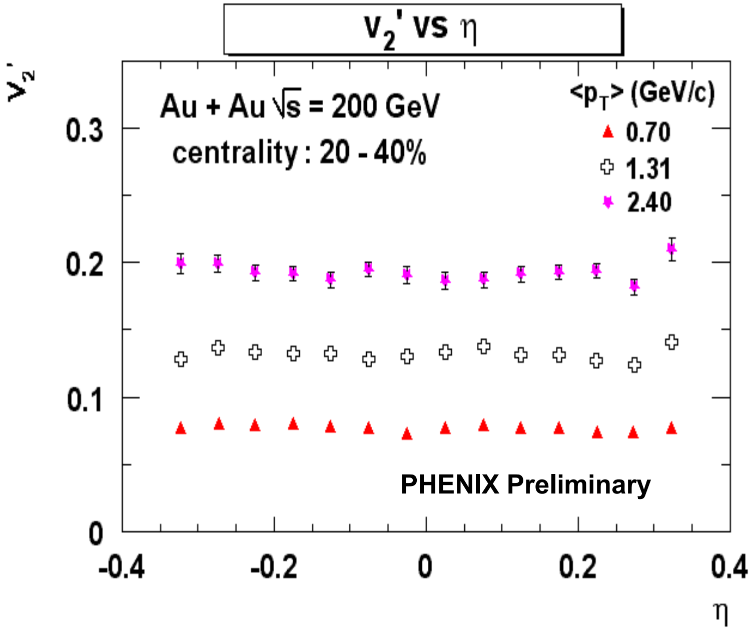
- Cumulant analysis: non-trivial PHENIX analysis
- Simulations performed using a toy model MC generator with PHENIX acceptance as input
- Results show that the v_2 extracted is robust and acceptance corrections are well implemented
- Differential measurements have been performed as a function of p_T, η, centrality, particle species





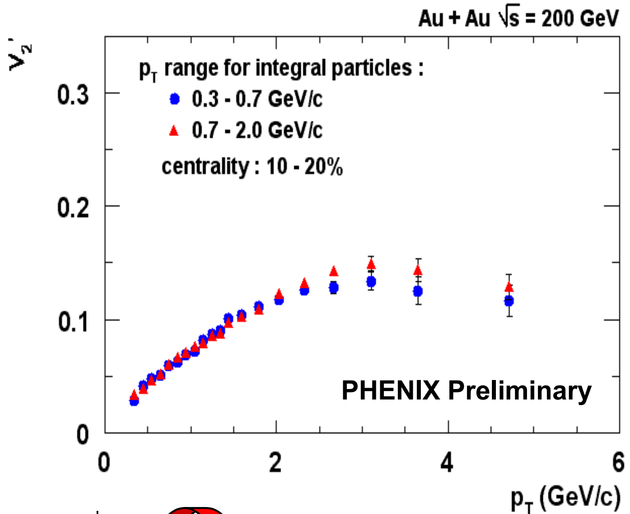
p_T and η dependence of v_2

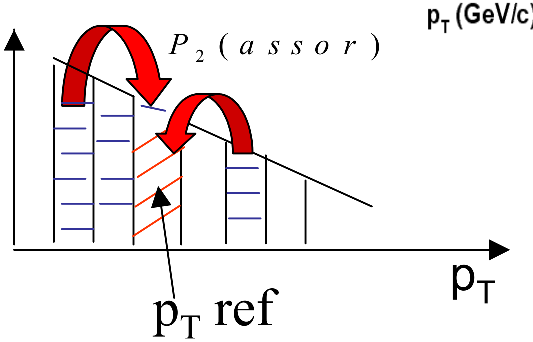


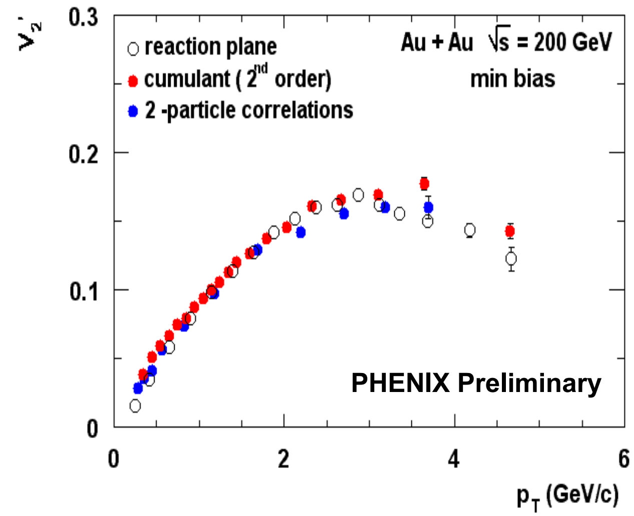


- Finite v_2 at high p_T : high p_T particles, probably associated with jets are correlated with low p_T particles from soft processes
- No apparent dependence of v2 on η over the PHENIX η coverage

Dependence on integral p_T range



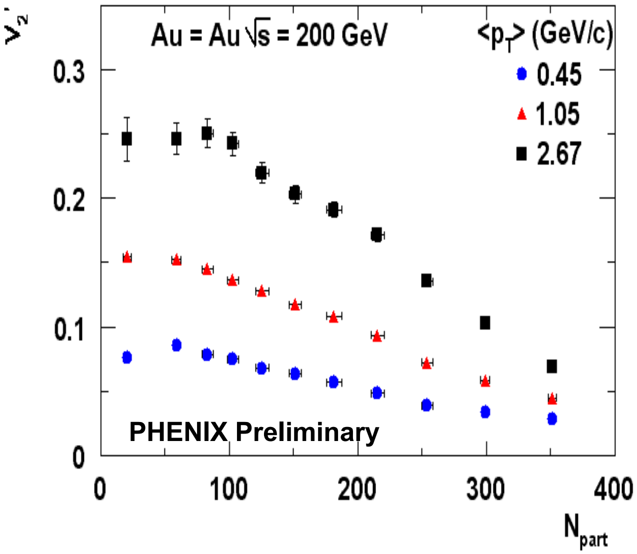


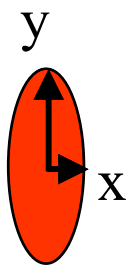


- Good agreement between values from second order cumulants and those from other methods

- Equivalent to assorted two-particle correlations
- No significant dependence on integral p_T of reference

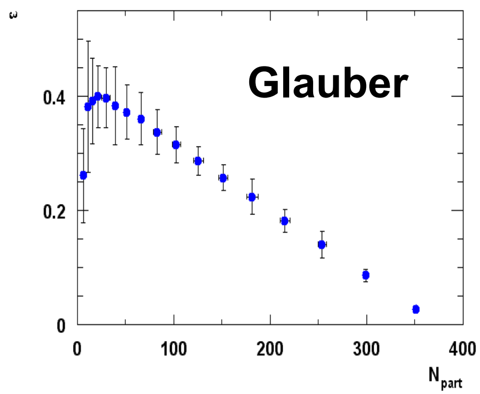
Differentiating between models

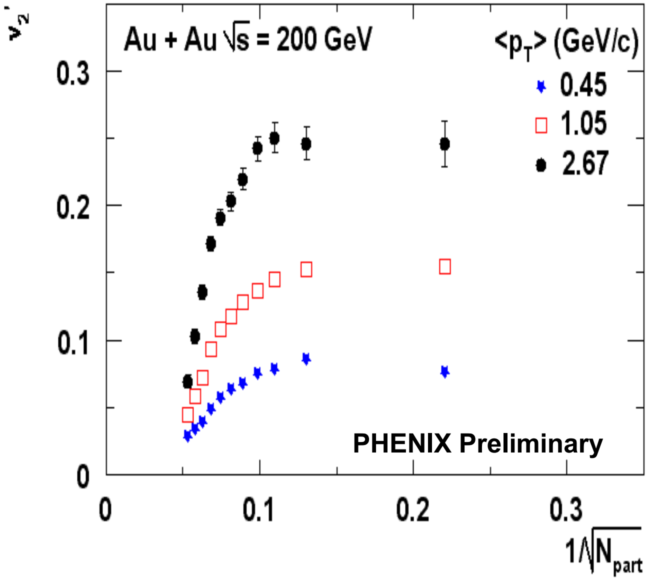




eccentricity

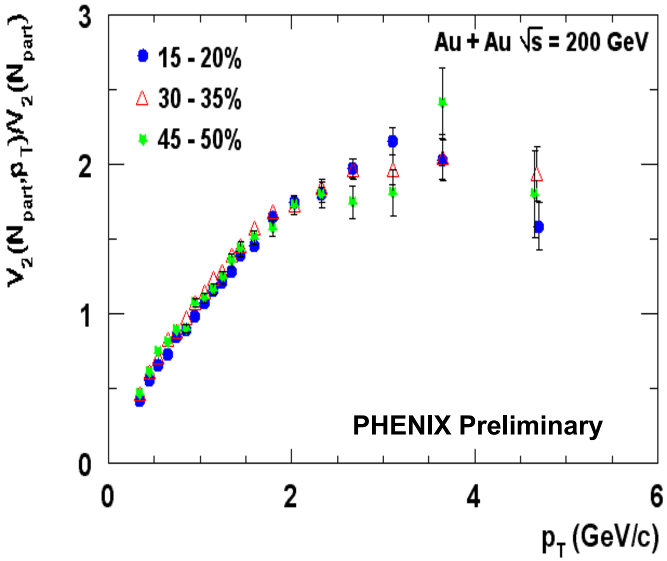
$$\varepsilon = \frac{<y^2> - <x^2>}{<y^2> + <x^2>}$$

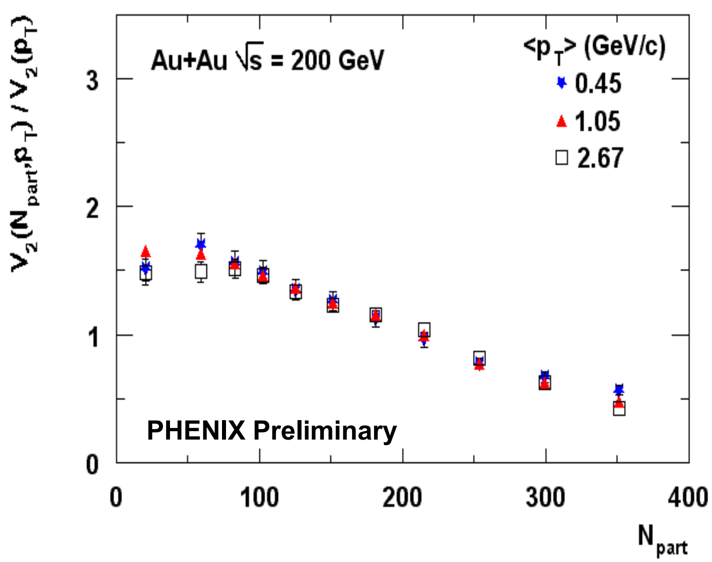




- Anisotropy driven by eccentricity : v_2 scales with N_{part}
- Model (Kovchegov) : v_2 scales with the (area of overlap)$^{-1/2}$ ($\sim 1/\sqrt{N_{part}}$)
  - ➢ true over a limited range of centrality
- Measurements help discriminate between models

Scaling of the anisotropy





- The differential anisotropy scales with the integral anisotropy
- Scaling property holds for both high and low p_T, indicating correlations between particles from these two regimes
- $v_2(b,p_T) \approx v_2(b)\, v_2(p_T)$

Summary / Conclusion

- **Differential azimuthal anisotropy has been measured in PHENIX using cumulants of azimuthal correlations performed**

- **These measurements indicate that:**

  - **High & low p_T particles are correlated**

  - **v_2 essentially independent of $p_{T\,ref}$**

  - **$v_2(b,p_T)$ factorizes in $v_2(b)v_2(p_T)$**

  - **There appears to be eccentricity scaling of v_2 at high p_T**

Results are compatible with correlation of jets with the reaction plane, as would be expected from jet quenching